APPENDIX 1

I.P.N. (ISO–PROPYL NITRATE) STARTING SYSTEM

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Introduction

1. The IPN (iso-propyl nitrate) starting system consists of an engine mounted turbine (rotor) driven starter motor and aircraft mounted fuel and electrical components. The starter motor rotor is driven by the gas generated during the decomposition of IPN fuel (AVPIN) in the starter motor combustion chamber. The resultant drive is transmitted, via an epicyclic reduction gear, to the engine.

2. A full description and operating details of the system are given in AP.103D–0208–16A. The system operating cycle, once initiated by the engine starter button, is fully automatic. A control unit, containing a timing motor, energized via a speed control switch in the starter motor gearbox, determines the sequence of operation and will shut down the system in the event of component failure or malfunction. The operating cycle is terminated, at a predetermined output shaft speed, by the speed control switch, or by a time switch in the control box.

3. The operation of the starter motor relies on the mono-fuel properties of the AVPIN fuel which decomposes under high temperature and pressure conditions, such as are created in the starter combustion chamber. At normal temperature and pressures the fuel burns readily when mixed with air.

4. The airframe mounted equipment controls the delivery of fuel to the starter motor combustion chamber and provides a supply of air, at the commencement of the operating cycle, for scavenging purposes. An ignition unit, energized via a fuel pressure operated ignition switch and connected to the starter motor igniters, provides initial combustion of the fuel/air mixture.

5. Pressure fuel and air for the starter motor are provided by a combined fuel pump, air blower and motor unit. The pump is supplied with fuel from a special tank in the aircraft and delivers the fuel to the starter motor via a high pressure (h.p.) switch and solenoid valve assembly, and the ignition switch. Blower delivery air is piped direct to the starter motor.

Modification standard

6. This appendix is technically up-to-date in respect of the following modifications. Information on modification titles, classification categories and mark applicabilities can be obtained by reference to the engine/ECU/type Modification Lists.

130	131	136	137	138	142
145	147	148	149	151	152
153	154	155	158	160	162
163	166	169	171	172	173
176	186	187	190	192	193
194	195	196	198	203	204
205	S.206	S.207	S.210	S.211	S.212
S.215	S.223	S.224	S.225	S.227	S.228
S.229	S.235	S.238	S.243	S.250	S.259
S.260	S.261	S.277	S.278	S.279	S.281
S.285	S.288	S.291	S.305	S.306	S.311
S.312	S.314	S.317	S.327	S.329	S.334
S.371	S.464	S.634	S.646	S.647	S.670
S.671	S.714	S.808	S.816	S.817	S.840(0)
S.849	S.858(0)	S.862(0)	S.866(0)	S.880	S.883
S.889	S.913	S.938	S.954	S.955	S.963
S.967	2018	2020	2104	2105	2106(T)
2108	2165	2166	2169	2212	2263
2264	2267	2332	2342		

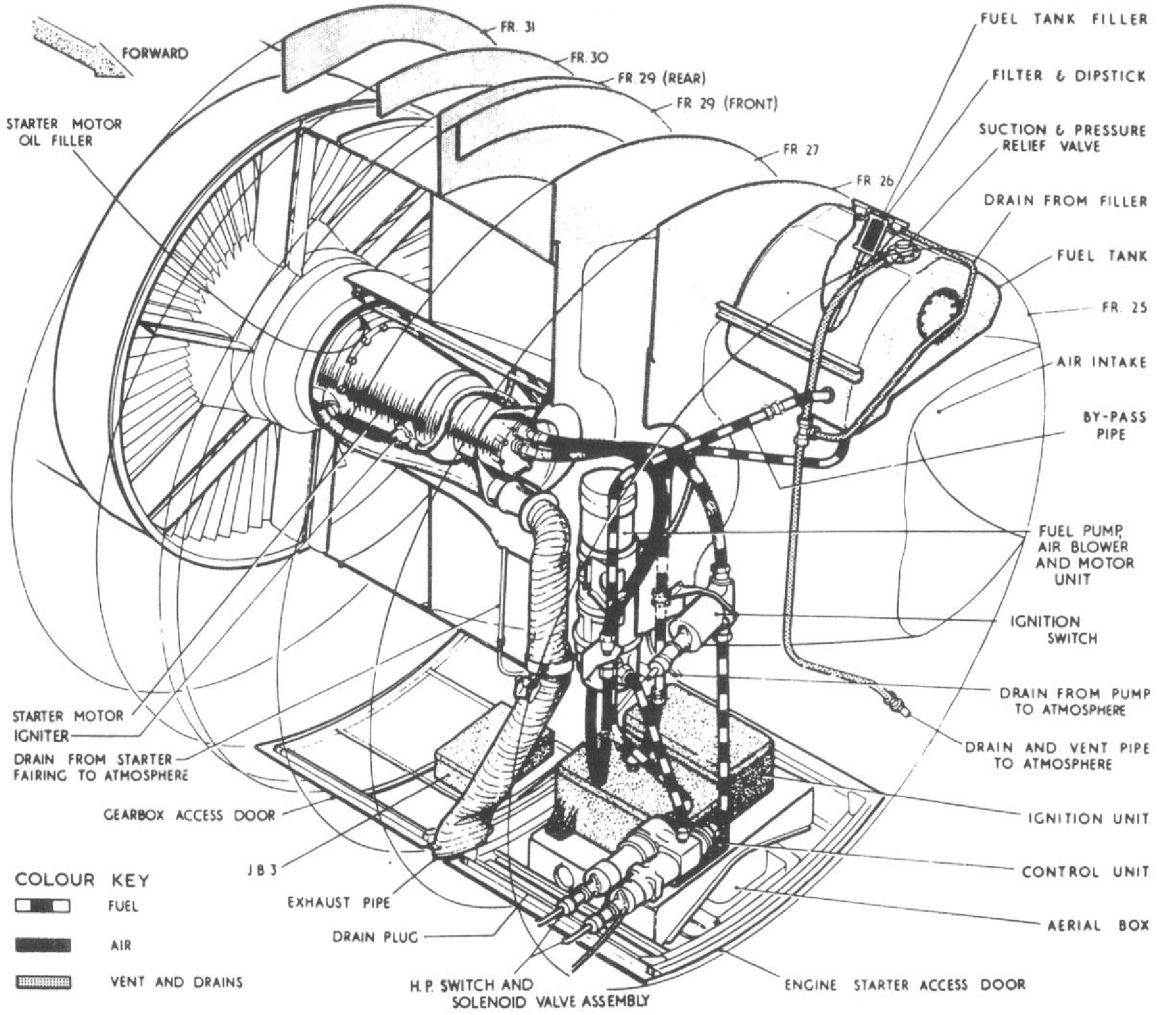


Fig. 1 Liquid fuel starter installation

SERVICING

WARNINGS . . .

(1) An IPN liquid fuel starter installation is a potential source of lethal injury to personnel and damage to Government property if the greatest care in handling and servicing, as detailed in this Appendix, is not observed.

(2) The combustion chamber and turbine are separated by a nozzle plate, also provided with a drain hole. Should the drain hole and any of the lower discharge nozzles become blocked, fuel will become trapped in the combustion chamber as shown in fig.1A. This constitutes a hazard which becomes more serious as the quantity of trapped fuel increases and under no circumstances must a start be attempted until any blockage has been cleared; if the quantity of trapped fuel exceeds 350 cm^3 an explosion will occur.

(3) Water flushing of the atomizer air valve, priming runs and fuel drainage checks are detailed in this Appendix and these, together with unsuccessful attempts to start (where combustion does not occur), may dislodge soot (products of combustion) which can cause blockage of the nozzle plate. An unsuccessful attempt to start (where combustion does not occur), a priming run or fuel drainage check each pass a similar amount of fuel into the combustion chamber.

(4) Not more than five starter operations, comprising unsuccessful attempts to start (where combustion does not occur) or starter operation for servicing purposes, may be made between successful starts (combination cycles) without examining the combustion chamber for fuel content as the last operation just prior to an attempt to start. The examining procedure for fuel content is included in 'Examine/clear combustion chamber nozzle plate' in this Appendix para.13.

(5) Personnel must not be positioned down the engine air intake or under the starter access door, or be in the vicinity of the starter, while carrying out simulated starts during the priming runs or the initial fuel drainage checks.

General

7. (1) Reference in the text to special tools, test fixtures and materials is made by 'item' number details of which are given in Table 1.

(2) Discard all tabwashers, 'O' ring seals, gaskets and locking wire on removal.

(3) 'O' ring seals should be fitted in the dry condition and the exposed surfaces lubricated with grease, Table 1 item 4.

(4) During assembly lubricate all threads with grease, Table 1 item 3.

(5) Only those cleaning agents listed in Table 1, or their equivalent substitute, should be used during servicing of the IPN starter components.

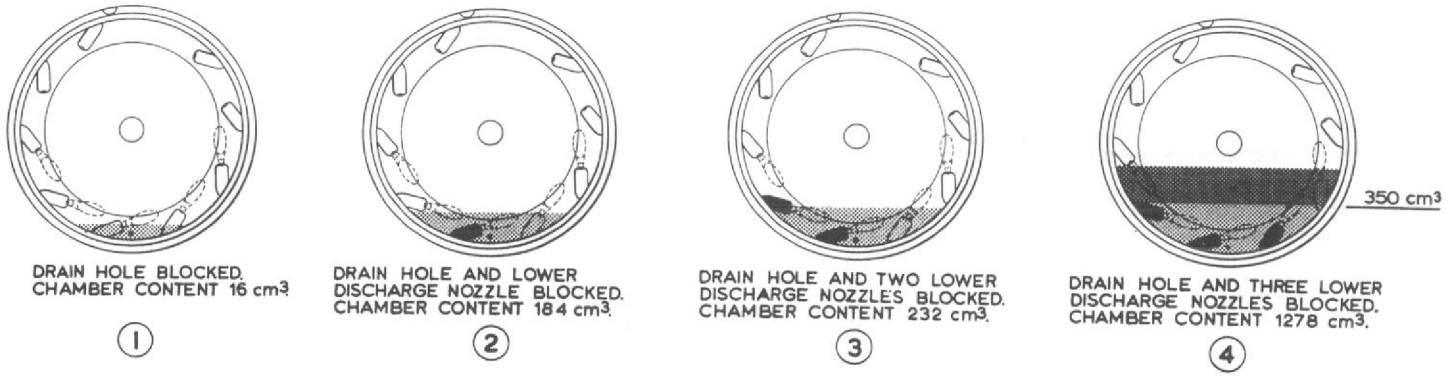
Note . . .

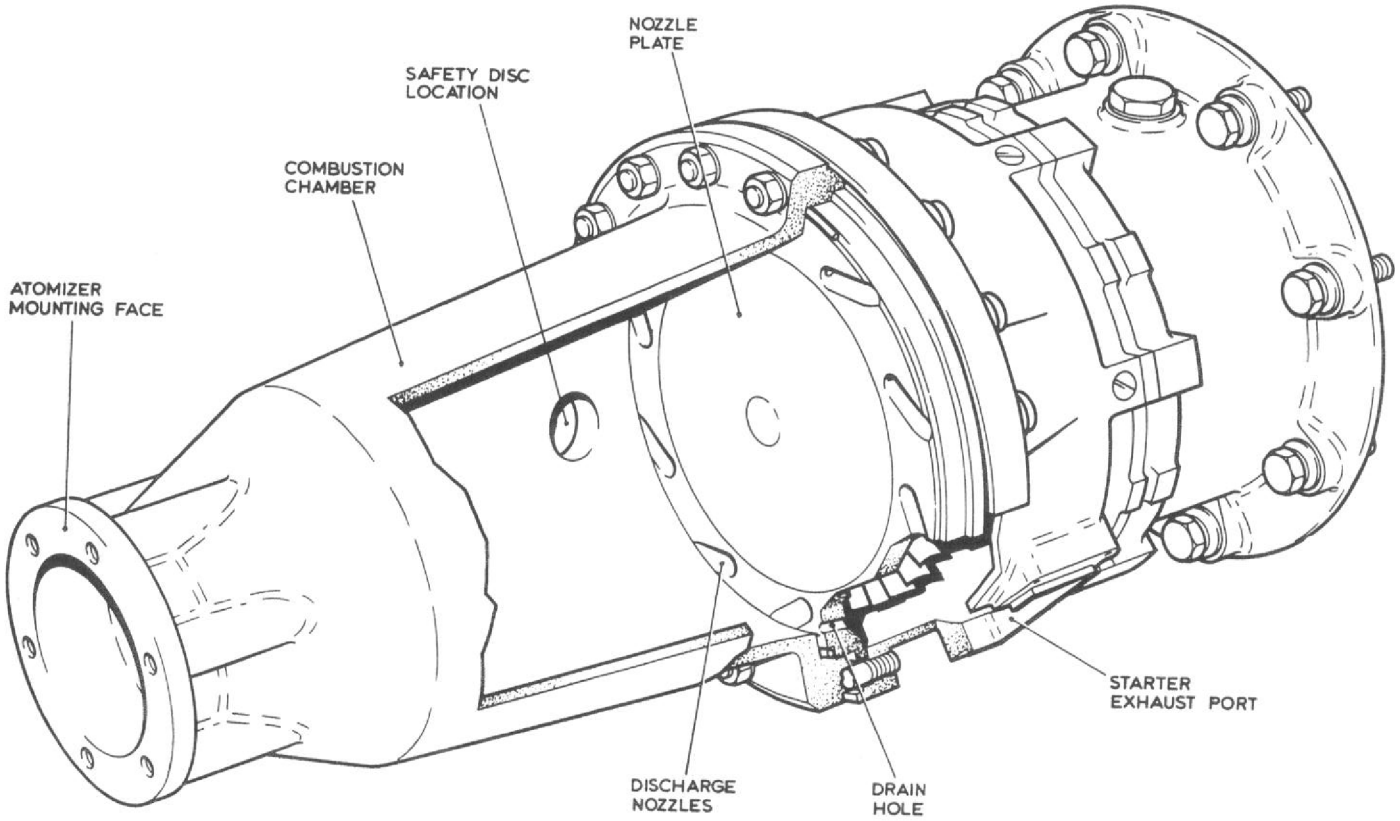
Under no circumstances should an alkaline based cleaning agent be used.

TABLE 1

Special tools, test equipment and materials

Item	Ref No.	Part No.	Description
1	5G/1621	–	Insulation resistance tester
2	–	558-2-01663	Special spanner – air valve sleeve
3	–	–	Grease ZX–13 (NATO code S–720)
4	–	–	Grease XG–250 (NATO code S–736)
5	–	–	AVPIN fuel
6	–	–	Locking wire DTD189 (22 S.W.G.)
7	33D/2201949	–	Trichloroethane
8	–	–	Oil OX–38 (NATO code 0-149)
9	–	–	Oil OM–170 (NATO code 0-115)
10	–	–	Acetone
11	33E/1322	–	Cleaning fluid – Methyl-ethyl-ketone





◀ Fig. 1A Blocked nozzle plate hazard ▶

Examination for damage and security

8. Examine and rectify as follows: –

(1) Remove light corrosion; reprotect exposed surfaces.

(2) Tighten loose nuts, bolts and screws (refer to Table 2).

(3) Renew faulty locking devices.

(4) Check for fuel leaks.

(a) renew faulty seals.

(b) renew damaged pipes.

(5) Examine fuel and air pipes for security and adequacy of protective sleeves (STI/Hunter/380A) and ensure that fuel vent pipe (Pt. No. C.201525/25) is free from chafing as far as possible.

TABLE 2

Torque loadings

Item	Torque load
Safety disc holder	384 lbf. in.
Atomizer securing bolts	180 lbf. in.
Igniter securing bolts	32 to 35 lbf. in.
Combustion chamber securing nuts/bolts	216 lbf. in.
Fuel-pipe-to-atomizer bolts	100 lbf. in.
Air pipe securing bolts	180 lbf. in.
Air dump valve cap retaining screws	20 lbf. in.
Gearbox to exhaust casing bolts	100 lbf. in.

Priming the fuel system

Note . . .

This procedure must be carried out after initial installation or when the fuel system has been disturbed, before attempting to operate the starter.

9. (1) Top up the fuel tank, to the upper mark on the dipstick, through the filter in the filler neck, with clean fuel, Table 1 item 5.

(2) Disconnect the 2-pin plug from the ignition unit (located on the starter access door), then connect a 24V lamp to the plug; this will render the ignition system inoperative and provide an indication of the fuel pressure in the pipe line to the atomizer.

Note . . .

Ensure that the input voltage is maintained within the specified limits during operation of the starting system. High or low input will give incorrect fuel drainage.

(3) Position a clean container under the exhaust outlet.

(4) Connect an electrical supply to the aircraft and adjust the input to between 23 and 26V d.c. on load.

(5) Depress the starter button to effect a simulated start; observe the lamp and check that: –

(a) A full airflow is evident at the starter exhaust for approximately three seconds.

Note . . .

Negligible airflow and audible indication that the air motor is labouring indicates a sticking atomizer air valve. The valve should be removed and cleaned as detailed in para.15.

(b) The fuel pump air blower and motor unit shuts down at the end of the three second air cycle.

WARNING . . .

If the fuel pump, air blower and motor unit continues to run on, this will discharge an excess amount of fuel into, or through, the combustion chamber and may cause soot (products of combustion) to be dislodged which can cause blockage of the nozzle plate. Where this situation occurs, the nozzle plate must be examined and cleared, as detailed in para.13, as the last operation just prior to an attempt to start.

(c) Pre-mod S647: The control box timer stops approximately 18 seconds after operation of the starter button.

(d) When the lamp is illuminated, fuel drains from the starter exhaust.

Note . . .

Where fuel drains from the starter exhaust but the lamp does not light up, a faulty l.p. switch and/or associated wiring is indicated.

WARNING . . .

Where the lamp is illuminated but no fuel drains from the starter exhaust, the nozzle plate drain hole must be examined and cleared as detailed in para.13.

(6) Repeat (5) as necessary, at one minute intervals until fuel drains from the exhaust.

WARNING . . .

Where more than four simulated starts are required before fuel drains from the starter exhaust, the nozzle plate drain hole must be examined and cleared as detailed in para.13.

(7) Effect a fuel drainage check as detailed in para.10.

Fuel Drainage Check

10.

WARNINGS . . .

(1) This check must not be effected until a minimum cooling period of one hour has elapsed since an attempted start during which combustion occurred.

(2) Under no circumstances must a start be attempted if the quantity of fuel drained, or the drainage pattern is other than specified.

(1) Top up, connect the 24V lamp and the ground electrical supply as detailed in para.9, sub-para. (1) to (3).

(2) Position a clean container (calibrated in cubic centimetres) under the exhaust outlet.

(3) Effect a simulated start and check as detailed in para.9, sub-para. (5).

WARNING . . .

If the fuel pump, air blower and motor unit continues to run on, this will discharge an excess amount of fuel into, or through, the combustion chamber and may cause soot (products of combustion) to be dislodged which can cause blockage of the nozzle plate. Where this situation occurs, the nozzle plate must be examined and cleared, as detailed in para.13, as the last operation just prior to an attempt to start.

(a) Measure and record the quantity of fuel drained from the starter exhaust; this should be within the limits 80 and 110 cm^3.

(b) Check for fuel leakage at the starter fairing drain; should any measurable fuel leakage be observed, the source of leak must be determined and the fault rectified.

(c) Observe the fuel drainage pattern.

Notes . . .

(1) Approximately three quarters of the total fuel drainage should occur in the first half minute and the remainder, other than odd drops, within the next minute.

(2) Where the fuel drainage does not follow the correct pattern in that the drainage stops early, or continues to drip steadily, or is less than the specified minimum, a blocked nozzle-plate is indicated.

WARNING . . .

A blocked nozzle plate constitutes a serious hazard. Under no circumstances must a start be attempted until the blockage has been cleared as detailed in para.13.

(4) Where the fuel drainage check is required as a result of fault diagnosis, sub-para (2) may be repeated once only.

Note . . .

Following a successful combustion cycle, where more than two fuel drainage checks are required during servicing, the combustion chamber must be examined for fuel content, as detailed in para.13, as the last operation just prior to an attempt to start. This limit takes due note of the three subsequent permitted attempts to start by the pilot.

WARNING . . .

Not more than five starter operations, comprising fuel drainage checks and unsuccessful attempts to start (where combustion does NOT occur) may be made between successful combustion cycles (or starts). Where more than five starter operations are required, during servicing, the combustion chamber must be examined for fuel content as detailed in para.13.

Note . . .

An unsuccessful attempt to start, where combustion does NOT occur, has the same effect on the IPN system, and passes the same amount of fuel, as a simulated start i.e. a priming run or a fuel drainage check.

(5) Remove all traces of fuel from the starter exhaust, then remove the container.

(6) Disconnect the lamp, then connect the 2-pin plug to the ignition unit.

Fuel Consumption Check

11. This check provides a guide to the overall efficiency of the system and the results obtained should be recorded.

(1) Top up the fuel tank, through the filter in the filler neck, with clean fuel, Table 1 item 5, to the upper mark on the dipstick. Note contents accurately.

(2) Connect a suitable voltmeter across the fuel pump, air blower and motor unit supply leads at a convenient position as near the motor as possible.

(3) Effect a start; note the duration, in seconds, of starter combustion and the voltmeter reading during combustion.

(4) Measure the quantity of fuel, in cm^3, required to replenish the tank to the original level [sub-para. (1)].

(5) Calculate the fuel consumption per second and compare the figure obtained with the value given in Table 3.

$$\text{Consumption per sec } (cm^3/S) = \frac{\text{Fuel required to replenish tank}}{\text{Duration of combustion}}$$

TABLE 3

Fuel consumption acceptance limits

Electrical input on load V d.c.	Fuel consumption rate Min.	Max.
	CM^3/S	CM^3/S
16	330	370
20	360	400
26	380	435

Electrical Checks

12. Whenever the IPN electrical system has been disturbed, check the relevant circuits for continuity and, using tester, Table 1 item 1 check that the insulation resistance is not less than 5 megohm. Refer to wiring diagram (Sect. 5, Chap.1, Group C1).

Examine/clear combustion chamber nozzle plate

13. (1) Remove both safety discs from the combustion chamber as detailed in para.31, sub-para. (1) (2) and (3), then using a suitable probe torch examine the combustion chamber for fuel.

(2) Where fuel is present, using a suitable wire, clear the nozzle plate drain hole and lower nozzles.

(3) Ensure that all fuel is drained from the combustion chamber, then install the safety discs as detailed in para.32.

(4) Carry out a fuel drainage check as detailed in para.10.

Free the atomizer air valve

14. Where the sticking atomizer air valve has been diagnosed as a cause of failure to start, the method detailed in sub-para. (1) should be used to free the valve, but, where there is an operational requirement, the method detailed in sub-para. (2) may be used to avoid the servicing penalty involved in water flushing.

Note . . .

Where persistant valve sticking occurs the defect should be rectified as detailed in para.15.

(1) Flush the atomizer air valve.

(a) Disconnect the atomizer air supply pipe from its connection at the bracket adjacent to the motor mounting.

(b) Connect a suitable air supply to the atomizer air supply pipe.

(c) Apply and gradually increase the air pressure until the valve opens. Release the pressure and disconnect the air supply.

(d) Raise the atomizer air supply pipe end up to the starboard wing tank relief valve access panel (second panel from the cabin) then, using a funnel, fill the pipe with hot water. Reconnect the air supply.

(e) Momentarily pressurize the air supply pipe to ensure that the water reaches the air valve, then allow to soak for 15 minutes.

(f) Apply a pressure of 30 lbf/in^2 to the air supply pipe for one minute to expel the water through the starter motor. Release the air pressure.

(g) Disconnect the air supply, then reconnect the atomizer air supply pipe and wirelock.

(h) Examine/clear the combustion chamber nozzle plate as detailed in para.13.

Note . . .

Where water flushing of the atomizer air valve is to be followed by other starter servicing, sub-para. (h) must be effected as the last operation just prior to an attempt to start.

(2) Free the atomizer air valve.

Note . . .

Whenever this method is used to free the atomizer air valve, the valve should be cleaned and examined, as detailed in para.15, at the next engine removal.

(a) Effect sub-para. (1) (a), (b) and (c).

(b) Reconnect the atomizer air supply pipe and wirelock.

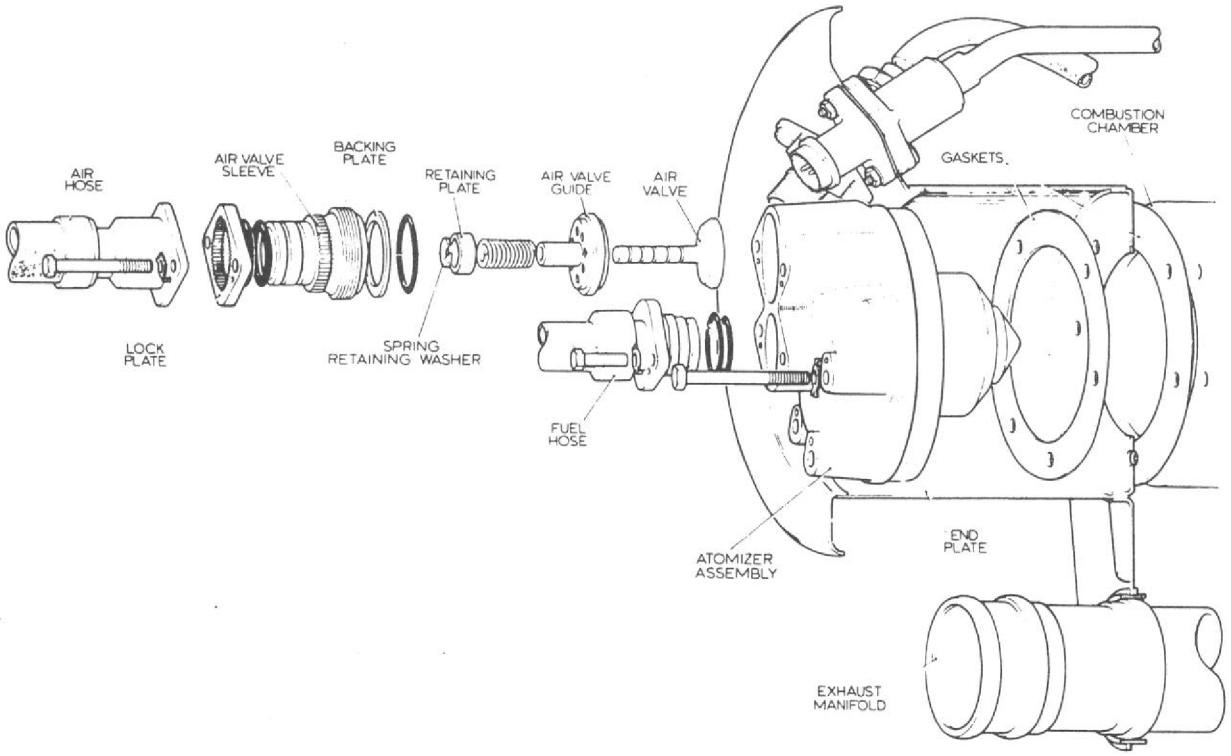


Fig.2 ▶ ◀ **Atomizer, hoses and air valve.**

◀ **Clean and examine the atomizer air valve (fig.2)**

15. Where persistent valve sticking occurs, the following method should be used to free the valve. ▶

(1) Remove the engine as detailed in Sect.4, Chap.1.

(2) Unlock and remove the bolts securing the air hose to the atomizer, then remove the hose; remove the air valve lock plate.

(3) Remove and discard the 'O' ring seals from the air valve sleeve then, using special spanner, Table 1 item 2, remove the sleeve.

(4) Remove the backing plate then remove and discard the 'O' ring seal.

(5) Remove the air valve assembly.

(6) Depress the air valve spring and remove the retaining washer; remove the retaining plate and separate the air valve, guide and spring.

(7) Immerse the air valve, guide and spring in boiling water and wash off the fuel deposits; dry with clean dry compressed air.

(8) Examine the air valve; flaking of the PTFE coating or damage to the valve seat will entail rejection of the valve and the guide.

(9) Examine the spring. Damage or distortion will entail rejection.

(10) Position the air valve in the guide, then locate the spring, over the stem, in the guide.

(11) Position the retaining plate, flange first, on the spring, then depress the plate and fit the retaining washer to the groove in the valve stem.

(12) Release the retaining plate ensuring that the washer locates in the bore of the plate.

(13) Position the air valve assembly, seat first in the atomizer air inlet port, then locate the 'O' ring seal in the recess formed round the valve guide.

(14) Position the backing washer on the seal and secure with the valve sleeve.

(15) Using special spanner, Table 1 item 2, fully tighten the sleeve, then locate the lock plate, spigot first and bolt holes aligned, on the valve sleeve splines.

(16) Fit the two 'O' ring seals to the air valve sleeve, then assemble the air hose to the sleeve and fit the bolts and new tab-washers.

(17) Torque tighten the bolts to the specified figure (Table 2) then lock by bending up the tabwashers.

(18) Install the engine as described in Sect.4, Chap.1.

Clean and examine the air blower filter (fig.3)

16. (1) Remove the fuel pump air blower motor unit as detailed in para.19.

(2) Remove the screws and washers securing the frame, then remove the frame, cover and filter gauze.

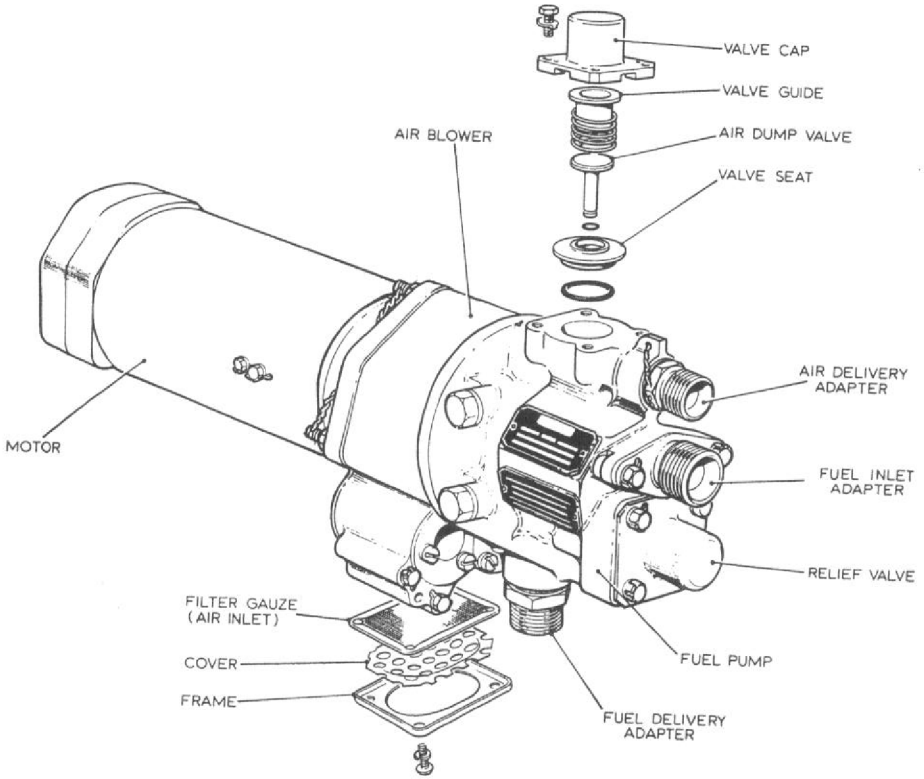


Fig.3 Motor, air blower and fuel pump

(3) Clean the filter gauze in cleaning fluid, Table 1 item 11, then dry with clean dry compressed air.

(4) Examine the filter gauze; damage and/or corrosion will entail rejection.

(5) Position the cover and the filter gauze in the frame, then locate the frame on the air blower inlet port.

(6) Secure the frame with the screws and spring washers; fully tighten the screws.

(7) Install the fuel pump, air blower motor unit as detailed in para.20.

Renew the air dump valve seals (fig.3)

17. (1) Remove fuel pump air blower motor unit as detailed in para.19.

(2) Unlock and remove the screws securing the valve cap to the fuel pump housing, then remove the valve cap, guide spring and dump valve; remove the 'O' ring seal from the valve.

(3) Remove the valve seat, then remove the 'O' ring seal from the seat.

(4) Using a clean, non-fluffy cloth moistened with trichloroethane Table 1 item 7, clean the components.

Note . . .

Care must be exercised to avoid damaging the rubber seat in the air dump valve during this operation.

(5) Examine the components for damage and corrosion; either of these faults will entail rejection.

(6) Fit the 'O' ring seals to the valve seat and the stem of the valve.

(7) Position the valve seat, spigot first, in the pump housing then locate the valve, stem first, in the pump housing.

(8) Position the valve guide, flange first, in the valve cap, then locate the spring on the guide.

(9) Assemble the valve cap, complete with guide and spring, to the pump housing, fit the screws and tabwashers and finger tighten screws.

(10) Ensure the gap between the valve cap flange and the pump body is equal at all four screw positions.

(11) Tighten the screws (progressively and in diametrically opposed sequence) to the torque loading specified in Table 2, ensuring that the flange gap is maintained and equal. Bend up the lock tabs.

(12) Install the fuel pump air blower unit as detailed in para.20.

REMOVAL AND INSTALLATION

General.

18. Prior to disconnecting or connecting electrical cables the aircraft must be rendered electrically safe (Sect.5, Chap.1, Group A1). On disconnecting electrical cables ensure that the cable ends and component terminals are suitably protected by fitting approved caps or polythene bags (Ref.No. 32B/1135–1138). Before disconnecting fuel pipes drain the starter fuel tank via the drain plug in the fuel pipe adjacent to the bottom of the fuel pump air blower and motor unit. After draining fit, tighten and wire-lock drain plug. Open ends of pipes and component open connections must be blanked off with approved caps or blanks.

Fuel pump air blower and motor unit

Removal

19. (1) Disconnect electrical cables from fuel pump motor, mounted on the front face of frame 27, and tie clear.

(2) Remove the locking wires and disconnect the fuel and air pipes from the unit. Slacken other ends of pipes and move clear.

(3) Remove the locking wire and disconnect the drain pipe from the unit. Move pipe clear.

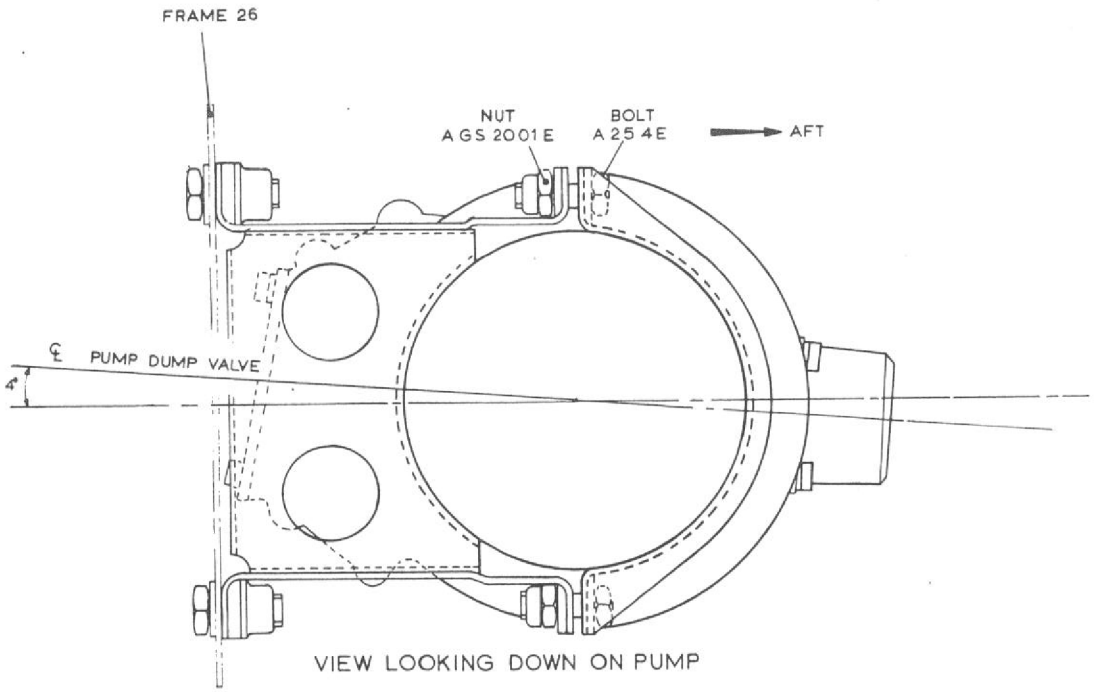


Fig.4 Motor, air blower and fuel pump assembly mounting brackets.

Installation

20. (1) Remove the bolts securing the terminal cover, then remove the cover.

(2) Using insulation tester, Table 1 item 1, check that the resistance between the motor terminals and the casing is not less than 0.5 megohms.

CAUTION . . .

On no account should the unit be run prior to installation as this may damage the fuel pump.

(3) Ensure that banjo body, banjo bolt and washer are fitted to the drain connection.

(4) Offer unit to mounting bracket, ensuring that the fuel pump dump valve cap faces aft and is clear of the exhaust pipe i.e. offset to port as shown in fig.4. Fit clips and secure with nuts and bolts.

(5) Re-connect fuel, air and drain pipes. Tighten and re-lock connections using stainless steel locking wire.

(6) Ensure that redundant connections are blanked off.

(7) Re-connect electrical cables to pump motor terminals.

(8) Restore electrical services to normal.

(9) Prime the fuel system (para.9).

(10) Effect a fuel drainage check as detailed in para.10.

H.p. switch and solenoid valve assembly.

Removal

21. (1) Disconnect electrical cables from h.p. switch and solenoid valve assembly, mounted on the aft face of frame 25, and tie clear.

(2) Disconnect all pipes from the assembly, slacken other ends of pipes and move clear.

(3) Remove the two bolts securing the assembly to the mounting.

Installation

22. (1) Remove the dust caps from electrical connections

(2) Using insulation tester, Table 1 item 1, check that the resistance between each plug pin and the frame and between pins A and C of the h.p. switch connection is not less than 5 megohms.

(3) Remove the dust caps from the inlet and outlet connections.

(4) Attach to mounting on frame 25 with bolts and washers. Ensure that a locking lug is fitted to the upper bolt.

(5) Re-connect all pipes, tighten and re-lock connections with stainless steel wire.

(6) Re-connect electrical cables to the assembly.

(7) Restore the electrical services to normal.

(8) Prime the fuel system as described in para.9

Ignition switch

Removal

23. (1) Disconnect electrical cable from l.p. ignition switch, mounted on a bracket on the front face of frame 26 and tie clear.

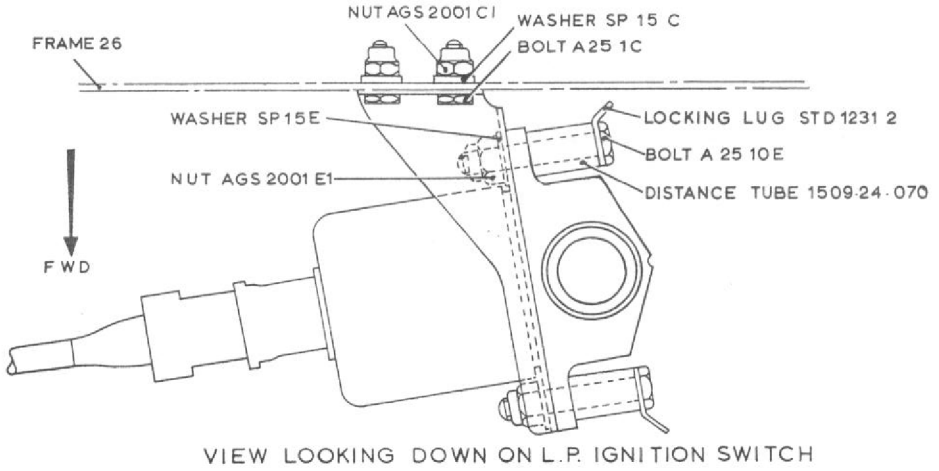


Fig.5 L.p. ignition switch installation

(2) Remove the locking wires and disconnect the fuel pipes from the switch. Slacken other ends of pipes and move clear.

(3) Remove two bolts, etc. securing the switch to the mounting bracket.

Installation

24. (1) Remove the dust cap from the electrical connection then, using insulation tester, Table 1 item 1, check that the resistance between each plug pin and the frame and between pins A and C is not less than 5 megohms.

(2) Remove the dust caps from the inlet and outlet connections, then suitably blank the outlet connection and connect the inlet to a low pressure air supply.

(3) With no air pressure applied check for continuity between pins A and B.

(4) Apply an air pressure of 70 lbf/in^2, then release the pressure.

(5) Repeat (4) four times.

(6) Apply a gradually increasing air pressure and check that the circuit is broken between pins A and B and made between pins A and C, at between 40 and 45 lbf/in^2.

(7) Decrease the pressure to 20 lbf/in^2. check that continuity is restored between pins A and B, then release the pressure and remove the test equipment.

(8) Fit the switch to the mounting bracket as shown on fig.5.

(9) Re-connect fuel pipes, tighten and wire-lock connections with stainless steel locking wire.

(10) Re-connect electrical cable.

(11) Prime the system as detailed in para. 9.

Ignition unit

Removal

WARNING . . .

Between switching off and commencing work on the unit, a minimum period of two minutes must elapse to allow the capacitors to discharge.

25. (1) Disconnect the electrical cables from the ignition unit mounted on the inside of the starter access door.

(2) Remove the three bolts securing the unit to the door, remove unit and ensure washers between unit and door are retained for subsequent installation.

Installation

26. (1) Fit the unit on the inside of the starter access panel using bolts (Pt. No. A. 25 3E), ensure that washers (Pt. No. SP. 16 E) are fitted between unit and door.

(2) Remove protective covers from the electrical connections and cables. Re-connect cables to unit.

WARNING . . .

Under no circumstances must the unit be energized without the igniters connected.

Control unit

Removal

27. (1) Disconnect the electrical cables from the control unit.mounted on the inside of the starter access door.

(2) Remove the four bolts securing the unit to the door, remove unit and ensure washers between unit and door are retained for subsequent installation.

Installation

28. (1) Remove the dust caps from the electrical connections.

(2) Pre-mod S647 units only; carry out the following check.

(a) Connect pin A of the 2-pin plug, via a suitable 'normally open' switch, to pin A of the red 4-pin plug.

(b) Connect a 24V d.c. electrical supply, positive to pin A, to the 2-pin plug.

(c) Momentarily close the switch; check that the time switch motor runs for approximately 18 seconds, then stops.

(d) Remove the test equipment.

(3) Fit the unit on the inside of the starter access panel using bolts (Pt. No. A. 25 3E), ensure that washers (Pt. No. SP. 16 E) are fitted between unit and door.

(4) Effect a fuel drainage check as detailed in para.10.

Starter motor

Removal

29. (1) Remove or roll out the engine as detailed in Sect.4, Chap.1.

(2) While supporting the starter motor remove the bolts securing the motor to the engine and remove the starter motor.

(3) Remove the drive coupling from the motor (if necessary) and refit to engine.

(4) Remove the air hose from the atomizer by unlocking and removing the bolts securing the hose to the atomizer.

(5) Remove the fuel hose from the atomizer by unlocking and removing the bolts securing the hose to the atomizer.

(6) Fit protective covers and blanks to the mounting flange, fuel inlet, air inlet, exhaust, igniter cable and speed probe cable connections.

Installation

30. (1) Remove the dust caps.

(1A) Check security of name and modification plates (para.40).

(2) Check the output shaft for freedom of rotation.

(3) Using tester, Table 1 item 1, check that the insulation resistance between the speed control switch plug pins and the frame is not less than 5 megohms at 500V d.c.

(4) Disconnect the cables from the igniter plugs then, using tester, Table 1 item 1, check that the insulation resistance between the conductor and braiding is not less than 5 megohms at 500V d.c. re-connect the cables then using locking wire, Table 1 item 6, lock the cable connectors to the plugs.

(5) Check for continuity between the speed control switch plug pins.

(6) Unlock and remove the oil filler plug and drain the starter motor of inhibiting oil; discard the tabwasher and temporarily refit the plug.

(7) Check that the oil feed hole in the mounting flange is clear.

(8) Prior to fitting fuel and air hoses suitably blank one end of each hose.

(9) Connect each hose, in turn, to a suitable rig filled with oil, Table 1 item 9 and pressurize as follows:

(a)	Air hose	200 lbf/in^2
(b)	Fuel hose	1250 lbf/in^2

(10) Check hoses for leakage over a period of two minutes; no leakage is permissible.

(11) Release the pressure then disconnect the hose from the pump.

(12) Flush the hoses with acetone, Table 1 item 10; then fit them to the starter motor Para.15, sub-para. (16) and (17) detail the procedure for fitting the air hose.

(13) Remove the drive coupling from the engine, fit on to the starter motor output shaft. Fit the starter motor on to the engine whilst engaging the drive coupling with the engine, lubricate bolt threads with oil OX–38, then fit and tighten to a torque load of 235 lb.f.in.

Note . . .
Ensure that the oil feed hole aligns with the corresponding hole in the engine and gasket.

(14) Prime the oil system

(a) Remove the oil filler plug, then using a suitable syringe inject 100 cm^3 of oil, Table 1 item 8 into the starter gearbox.

(b) Fit a new 'O' ring seal to the oil filler plug, then fit the plug and a new tabwasher.

(c) Fully tighten the filler plug, then lock by bending up the tab-washer.

(15) Install the engine as described in Sect.4, Chap.1.

(16) Prime the fuel system as detailed in para.9.

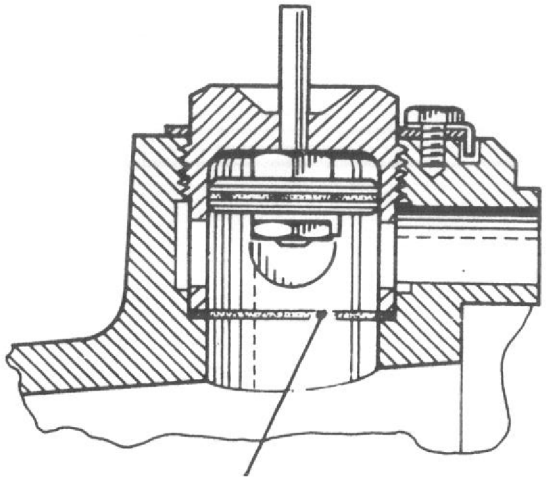


Fig.6 Sectional view of sheared safety disc

◀ Safety discs (fig.6 and 6A) ▶

Removal

CAUTION . . .
Safeguard all tools and parts removed to prevent them falling into the engine.

31. (1) Enter the air intakes and remove access panels from air intake inner skins.

(2) Unlock and remove the safety disc locking screws.

(3) Remove the star locking washers, then remove the disc holders.

(4) Remove the sheared outer edge of the discs from the seatings in the combustion chamber, then remove any carbon deposits from the seatings.

Note . . .
Care must be exercised to avoid damaging the seatings during this operation.

(5) Take the disc holders to the bench.

(6) Remove and discard the discs from the holders.

Installation

Note . . .
On completion, an independent check should be carried out to ensure that no foreign objects have been left in the air intakes or have dropped into the engine.

32. (1) Position the safety disc, stem first in the holder.

(2) Apply an even coating of grease, Table 1 item 3, to the threads of the holder.

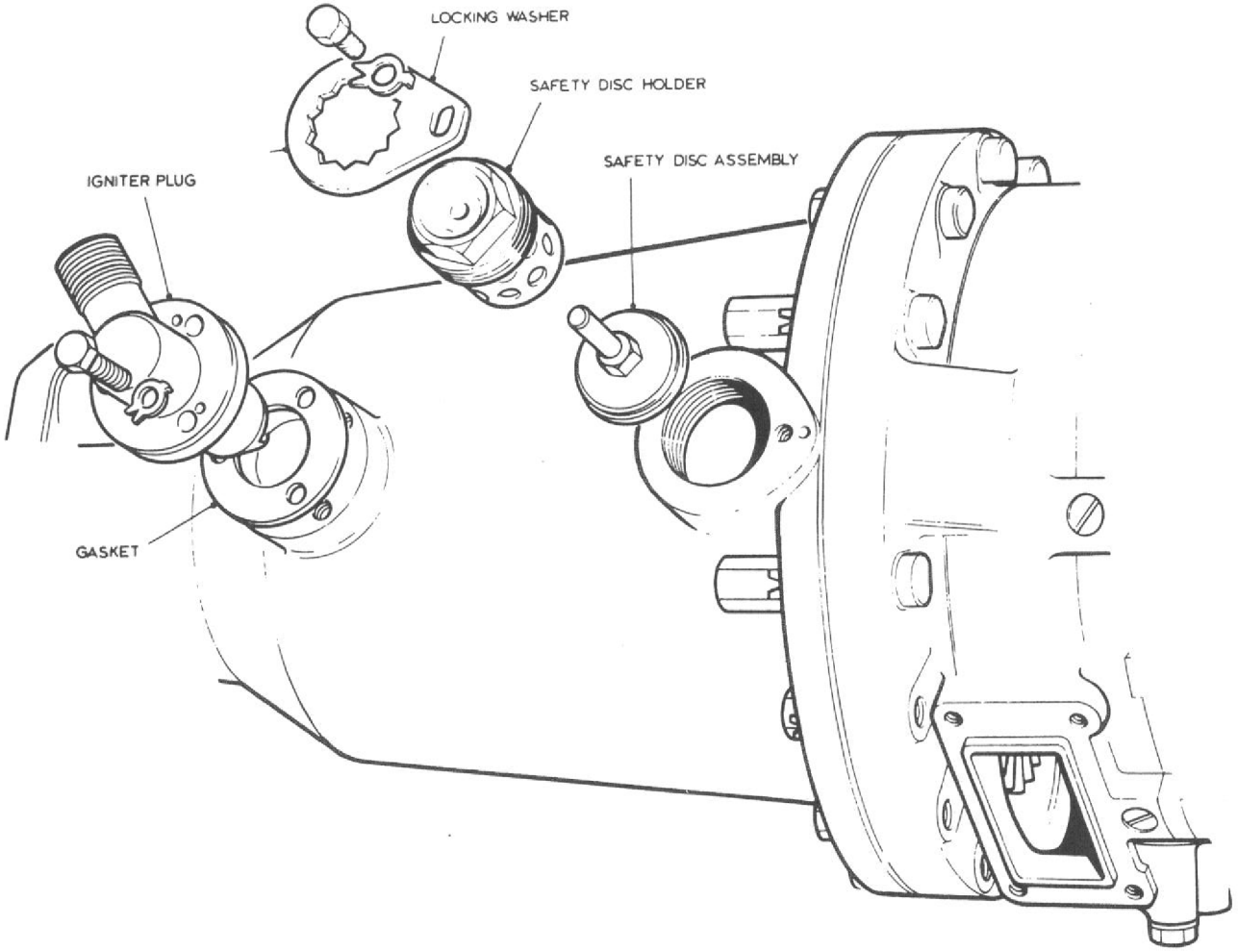
(3) Then enter the air intakes and install the holders in the combustion chamber and torque tighten to the specified figure (Table 2).

(4) Position the star locking washer, aligning the locking screw hole, on the holder and secure with the locking screw and tabwasher.

(5) Fully tighten the screw and lock.

(6) Refit access panels on inner skins of air intake.

(7) Thoroughly examine the engine to ensure that nothing has dropped into the engine. Then remove all tools etc. from the air intakes.



◀ Fig. 6A Igniter plug and safety disc ▶

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Igniter cable(s)
Removal

33. After removing the engine (Sect.4, Chap. 1) proceed as follows:–

(1) Cut the locking wire and remove the cable(s) from the end plate connector.

(2) Cut the locking wire and remove the cable(s) from the igniter plug(s).

Installation

34. The cables should be installed prior to engine installation as follows:–

(1) Assemble the cable(s) to the end plate connector(s) and fully tighten.

(2) Using wire, Table 1 item 6, wirelock the cables to each other.

(3) Assemble the cable(s) to the igniter plugs and fully tighten.

(4) Using wire, Table 1 item 6, wirelock the cable(s) to the lug(s) provided on the igniter plug(s).

Igniter plug(s)
Removal

Note . . .
Safeguard all tools and parts removed to prevent them falling into the engine.

35. (1) Enter air intakes and remove access panels from inner skins of air intake.

(2) Unlock and remove the cable connector from the igniter plug.

(3) Note the angular relationship of the igniter cap to the combustion chamber, then unlock and remove the securing bolts.

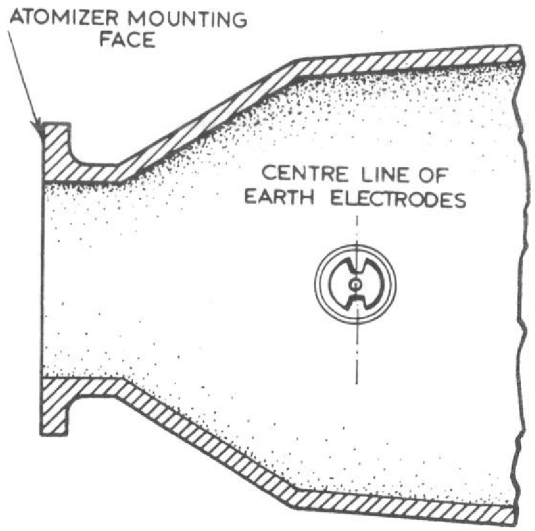

Fig.7 Orientation of igniter plug.

(4) Remove the igniter plug, then remove the gasket.

Note . . .
Two 2BA tapped holes are provided in the body flange for extraction purposes.

(5) Secure the plug body to the plug cap with the transportation nuts and bolts.

Installation

Note . . .
On completion an independent check should be carried out to ensure that nothing has been left in the air intakes or dropped into the engine.

36. (1) Remove the transportation nuts and bolts, then separate the plug cap from the plug body.

(2) Position the gasket on the plug body, then insert the body with the earth electrodes positioned at right-angles to the starter axis as shown in fig.7.

(3) Position the plug cap, orientated as noted in para. 35 (3), on the body and secure with the bolts and tabwashers.

(4) Torque tighten the bolts to the specified figure (Table 2) and lock by bending up the tabwashers.

(5) Assemble the cable connector to the igniter plug and fully tighten.

(6) Using wire, Table 1 item 6, lock the cable connector to the plug.

(7) Refit access panels on inner skin of air intakes.

(8) Thoroughly examine the engine to ensure that nothing has dropped into the engine and remove all tools, etc. from the air intakes.

Atomizer (fig.2)
Removal

37. After removing the engine (Sect.4, Chap. 1) the atomizer is removed as follows:–

(1) Unlock and remove the bolts securing the air hose to the atomizer, then remove the hose.

(2) Unlock and remove the bolts securing the fuel hose to the atomizer, then remove the hose.

(3) Unlock and remove the bolts securing the atomizer, then withdraw the atomizer from the combustion chamber.

Note . . .
The atomizer, fuel and air hose securing bolts, which are lifed to the starter, must be retained with the starter motor.

(4) Remove and discard the atomizer gasket.

(5) Fit the fuel port, air valve and atomizer dust covers and secure with the nuts, bolts and packing pieces.

Installation

38. The atomizer should be installed prior to engine installation as follows:—

(1) Check that the nozzle plate drain hole and nozzles in the combustion chamber are completely clear, then using a suitable suction type cleaner remove any loose carbon from the chamber; re-check the drain hole and nozzles.

(2) Remove the nuts, bolts and packing pieces securing the dust covers, then remove the covers.

Caution . . .

On no account must the transportation bolts retaining the dust covers be used to secure the atomizer to the starter motor and/or the fuel and air hoses to the atomizer.

(3) Assemble the atomizer, interposing the gasket to the end plate, and secure with the bolts and tabwashers.

Note . . .

The air valve is located adjacent to the speed control cable plug.

(4) Ensure that the 'O' ring seals are located in their recesses provided and the locking plate is located on the air valve sleeve and aligned with the bolt holes, then assemble the air hose to the sleeve and secure with the bolts and tabwashers.

(5) Torque tighten the atomizer and air hose retaining bolts to the specified figure (Table 2).

Note . . .

The bolts must be tightened evenly, in turn, to avoid distortion of the atomizer.

(6) Fit the 'O' ring seals to the fuel hose, then assemble the hose to the atomizer and secure with the bolts and tabwashers; torque tighten the bolts to the specified figure (Table 2).

Starter motor fuel and air pipes (STI/Hunter/380A)

39. These pipes must be fitted with protective sleeving to prevent them chafing the aircraft fuel system vent pipe (Pt. No. C.201525/25). When replacing the pipes ensure that the sleeves are intact and suitably positioned. If not replace the sleeving using sleeving, heat shrinkable, black 1¼in. (Ref. No. 5F/4342167). On installing the engine ensure that the sleeving provides adequate protection.

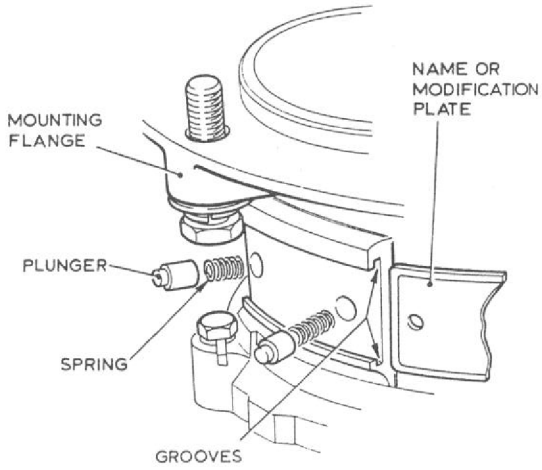

Fig.8 Starter motor name or modification plate attachment.

Security of starter motor name and modification plates — STI/Misc/326 (fig.8)

40. Examine the name plate and modification plates respectively to determine whether they are secure as follows:—

(1) The two plungers are correctly located in the holes in the plate.

(2) The plate is correctly located in the grooves on the starter flange. This can best be achieved by gently lifting either end of the plate to ensure that it does not come free of the locating grooves, at the same time being careful not to distort the plate across its width.

(3) If a nameplate or modification plate is found to be defective, remove it from the starter complete with its retaining springs and plungers and retain.

(4) If it is necessary to remove a name plate, mark the serial number of the starter on the starter flange using lacquer —opaque yellow. This will enable the starter to be referenced to its log book which contains all relevant information. Discard the nameplate.

(5) Using lacquer — opaque yellow, mark "STI/MISC/326" at any convenient point on the flange of the starter.

FAULT DIAGNOSIS AND RECTIFICATION

General

41. Faults which may be encountered during service are listed in Table 4 together with their possible causes and the appropriate remedial action to be effected. In the Table no account is taken of incorrect supply voltage, faulty installation or obvious defects.

TABLE 4

Fault diagnosis and rectification

Fault	Cause	Remedy
Starting system fails to operate on selection.	No supply to control unit.	Check 10 amp. fuse; renew if necessary. If fuse blows on subsequent start, refer to '10 amp fuse blows during starting cycle'. Refer to the aircraft wiring diagram (Sect.5, Chap.1, Group C1) and check the supply to the control unit and the start button circuit. Rectify if necessary.
	Speed control switch open circuit	Disconnect the lead from the control unit blue four pole plug, then check for continuity between the lead sockets A and D. If satisfactory reconnect socket. If an open circuit is indicated, check the wiring between the socket and the speed control switch; rectify as necessary. If the wiring is satisfactory, reject the starter motor for a faulty speed control switch.
	Faulty control unit	Pre Mod. S647 only, disconnect the LT supply lead at the ignition unit, then select a start and check that the control unit time switch motor can be heard running. If faulty, reject the control unit. In all cases, connect a suitable circuit tester across the motor contactor LT terminals then select a start. A live circuit should be indicated during the control unit cycle. If a dead circuit is indicated. check the wiring to the contactor, rectify as necessary. If the wiring is serviceable, reject the control unit.
	No supply to fuel pump, air blower and motor unit.	Refer to the aircraft wiring diagram (Sect.5, Chap.1, Group C1). Check the power supply to the contactor and the motor terminal, rectify as necessary.
	Faulty motor contactor	Refer to A.P.4343D, Vol.1, Book 2, Sect.10. Function check the contactor, reject if faulty.
	Faulty fuel pump, air blower and motor unit.	Reject fuel pump, air blower and motor unit.
10 amp. fuse blows during starting cycle	Short circuit	Refer to the aircraft wiring diagram (Sect.5, Chap.1, Group C1). Disconnect as necessary and check the aircraft wiring for a short to earth. Rectify as necessary.
	Faulty h.p. switch or solenoid valve.	Check the insulation resistance between pins A and C on the h.p. switch. Check the solenoid valve insulation resistance. If faulty reject h.p. switch and solenoid valve assembly.
	Faulty H.T. lead/igniter	Disconnect as necessary and check leads and igniters for a short to earth. Reject faulty components.

TABLE 4 (Contd)

Fault	Cause	Remedy
	Faulty control unit	Substitute the control unit for one of known serviceability, then attempt a start. If satisfactory, reject original control unit.
	Faulty ignition unit.	Reject.
Starting system shuts down on release of start button.	Faulty aircraft wiring	Refer to the aircraft wiring diagram (Sect.5, Chap.1, Group C1). Check the wiring between the motor contactor positive terminal and the h.p. switch lead socket A; h.p. switch lead socket B and the ignition switch lead socket A; the ignition switch lead socket B; and the control unit red lead socket D. Renew faulty wiring as necessary.
	Faulty ignition switch	Using a 500V megger, check that the insulation resistance between each plug pin and the frame and between pins A and C is not less than 5 megohms. Check for continuity between pins A and B. If faulty, reject the ignition switch.
	Faulty h.p. switch	Using a 500V megger, check that the insulation resistance between each plug pin and the frame and between pins A and C is not less than 5 megohms. Check for continuity between pins A and B. If faulty reject the h.p. switch and solenoid valve assembly.
	Control unit	Reject control unit.
Starter motor fails to light up (systems shut down after 3 seconds).	Low aircraft supply voltage	Rectify as necessary.
	Empty fuel tank	Check fuel contents; top up, if necessary.
	Fuel contaminated by water	Drain the system, flush with clean fuel, then refill. Carry out fuel drainage checks until satisfied the fuel is clean, ensuring that the amount of fuel drained is recorded at each check. **WARNING . . .** **(1) Water may dislodge combustion products and block the nozzle plate drain hole. This is a serious hazard — do not attempt to start until drain hole is clear.** **(2) Observe all precautions detailed in para. 9 and 10.**

TABLE 4 (Contd)

Fault	Cause	Remedy
Starter motor fails to light up (systems shut down after 3 seconds) (Contd).	Leaking fuel system	Carry out a fuel drainage check. Record the amount of fuel drained from the starter motor exhaust and check the system for leaks; rectify leaks as necessary. If the fuel drainage is less than the specified minimum and no leaks are found, refer to 'Fuel drainage less than specified minimum'.
	Sticking atomizer air valve.	Disconnect the L.T. supply at the ignition unit, then select a start. Check that the motor unit runs normally with no audible indication of labouring and that air flows from the exhaust pipe. If the motor labours a sticking air valve is indicated. Flush the air valve as detailed in para.14.
	Faulty ignition switch	Connect a suitable circuit tester across the ignition unit L.T. supply lead socket, then select a start. Check that a live circuit is indicated momentarily (0.2 seconds) before the system shuts down. If a faulty circuit is indicated check the wiring between the ignition switch and the ignition unit; rectify as necessary. If the wiring is satisfactory, remove the ignition switch, check the insulation resistance and effect a functional check; reject switch if faulty.
	Negative pressure inside ignition unit (Aircraft last flight at or above 40,000 ft).	Release the red painted screw in the ignition unit cover (Pre-mod S889) or press the plunger in the ignition unit body (Mod.S889). Allow one minute for the air pressure to return to ambient, then tighten the screw or release the plunger. Attempt a start.
	Faulty ignition system.	Disconnect the HT ignition leads and check for continuity and, using a 500V megger, that the insulation resistance is not less than 5 megohms. Renew faulty lead. Remove the igniter and carry out a function check using an ignition unit of known serviceability; renew faulty igniters. If the igniters and HT leads prove to be serviceable, reject the ignition unit.
	Air blower inlet filter filter obstructed	Examine; rectify as necessary.
Combustion not sustained (Starter motor shuts down before reaching cut-out speed)	Blown safety disc	Check, renew, if necessary. Note . . . *Where repeated safety disc failures occur, the starter motor should be rejected for overhaul.*

TABLE 4 (Contd)

Fault	Cause	Remedy
Combustion not sustained (Starter motor shuts down before reaching cut-out speed) (Cont'd).	Empty fuel tank.	Check. Top up as necessary.
	Restriction in supply to fuel pump	Check the fuel tank and pipes for obstruction and the tank inward vent valve for damage. Rectify as necessary.
	Loss of fuel pressure (leakage)	Check the system for leaks and effect a fuel drainage check (para.10). Rectify any external leaks as necessary. If no external leaks are found and the fuel drainage is not satisfactory refer to 'Fuel drainage less than specified minimum'.
	Faulty speed control switch or h.p. switch and solenoid valve.	Refer to the aircraft wiring diagram (Sect.5, Chap.1, Group C1) and check the wiring to the speed control switch. Rectify as necessary. If the wiring is satisfactory, reject the H.p. switch and solenoid valve. If the fault persists, reject the starter motor for a faulty speed control switch.
'Popping' in starter motor during air cycle when starter is hot.	Failure of air dump valve 'O' ring seal	Disconnect the air pipe from the fuel pump then, with the ignition unit 2-pin plug and solenoid valve plug disconnected, initiate a start. Check the air port in the fuel pump for fuel; any leakage will entail renewal of the air dump valve 'O' ring seal.
	Faulty h.p. switch and solenoid valve.	Reject
Low engine cranking speed	Partially seized starter motor	Reject
	Faulty air motor blower and pump unit.	Reject
	Faulty h.p. switch and solenoid valve.	Reject
Starter motor fails to turn	Faulty engine	Refer to A.P.102C-$\frac{1503}{1507}$-1. Check the engine for freedom.
	Seized starter motor	Reject

TABLE 4 (Contd)

Fault	Cause	Remedy
Fuel drainage less than specified minimum and/or low fuel consumption	Blockage of nozzle plate ▶ ◀	Clear as detailed in para.13.
	Faulty control unit	Effect a fuel drainage check (para.10) using a control box of known serviceability. If fuel drainage is acceptable, reject the original control unit.
	Faulty fuel pump or motor unit	Reject fuel pump, air blower and motor unit.
	Solenoid valve sticking	Disconnect the lead from the solenoid valve, then using a suitable supply, exercise the valve six times. Failure to operate or sluggish response will entail rejection of the h.p. switch and solenoid valve assembly.
Fuel drainage excessive	Short circuit ignition switch	Check aircraft wiring to ignition switch. Rectify as necessary. If wiring is serviceable function test ignition switch. Reject if faulty.
	Faulty control unit.	Carry out a fuel drainage check (para.10) using a control unit of known serviceability. If the fuel drainage is acceptable reject the original control unit.
	Failure of air dump valve 'O' ring seal or faulty h.p. switch.	Refer to 'popping' in starter motor during air cycle when starter is hot.
Incorrect fuel drainage pattern.	Blocked nozzle plate ▶ ◀	Clear as detailed in para.13.
	Leaking atomizer	Roll out engine. Remove, dismantle and clean the atomizer. Check the fuel valve for leaks.

TABLE 4 (Contd)

Fault	Cause	Remedy
Fuel pump, air blower and motor unit continues to run on after 3 second cycle	Faulty control unit	Substitute the control unit for one of known serviceability. If satisfactory – reject original control unit. If not satisfactory – check aircraft wiring.